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Errata

Page 241, line 10, for "created" read "reached."
Page 271, line 8, for "*Cyas*" read "*Cycas*."
Page 383, line 3, for "Law or" read "Lawn on."

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JANUARY, 1918

Studies in the genus Lupinus—II. The Microcarpi, exclusive of Lupinus densiflorus

CHARLES PIPER SMITH

(WITH SIXTEEN TEXT FIGURES)

INTRODUCTION

The subgenus *Platycarpos* of Watson readily permits separation into two groups, the *Pusilli* of Heller (Muhlenbergia **8**: 87. 1912), or the loosely-flowered small species of the interior of western North America; and the *Microcarpi* (Bull. Torrey Club **44**: 405. 1917), or the verticillate and commonly larger plants of the Pacific Slope of both North America and central Chile.

The published names applied to members of the *Microcarpi* are as follows:

L. microcarpus Sims, Bot. Mag. **50**: *pl. 2413*. 1823.
L. densiflorus Benth. Trans. Hort. Soc. II. **1**: 409. 1835.
L. Menziesii Agardh, Syn. Gen. Lup. 2. 1835.
L. palustris Kell. Proc. Cal. Acad. Sci. **5**: 16. 1873.
L. Menziesii aurea Kell. *ibid.* **5**: 16. 1873.
L. lacteus Kell. *ibid.* **5**: 37. 1873.
L. luteolus Kell. *ibid.* **5**: 38. 1873.
L. Bridgesii Gray; Watson, Proc. Am. Acad. **8**: 538. 1873.
L. malacophyllus Greene, Pittonia **1**: 215. 1888.
L. ruber Heller, Muhlenbergia **2**: 75. 1905.
L. arenicola Heller, *ibid.* **2**: 75. 1905.
L. horizontalis Heller, *ibid.* **2**: 74. 1905.
L. glareosus Elmer, Bot. Gaz. **39**: 53. 1905.
L. subvexus C. P. Smith, Bull. Torrey Club **44**: 405. 1917.

[The BULLETIN for December (**44**: 535–579. *pl 25, 26*) was issued December 27, 1917.]

L. Bridgesii Gray is evidently the same as *L. luteolus* Kell. and is so acknowledged by Watson (Bib. Index 238). *L. arenicola* has been referred by Heller (Muhlenbergia **6**: 70) to *L. lacteus* Kell., which, as noted by Heller, was referred by Watson first to *L. densiflorus* and later to *L. microcarpus*. *L. malacophyllus* Greene might easily be considered as a connecting link between the *Pusilli* and the *Microcarpi*. Since so many variations occur, it is really surprising that no more names have been published. Several specimens have been marked "var." by the collector or student; but evidently no one has cared to attempt a critical study of the group. Except for the material easily determined as *L. luteolus* Kell., most specimens have been labeled either *L. microcarpus* or *L. densiflorus*, or left unnamed.

During four years of field observations in middle western California, my efforts to determine the variations I collected led to unsatisfactory results, and a survey of the material found in the herbaria visited in 1908 brought me to the determination to some day seek a classification that might possibly eliminate some of the evident confusion as to proper identifications. With this object in mind, I recently undertook to look into the status of the forms already described, and then to work out the relationships and characters of the seemingly undescribed forms known to me.

MATERIAL EXAMINED

The National, Stanford University, and University of California herbaria kindly placed many sheets in my hands for study. Two weeks were spent in Cambridge, New York, and Philadelphia, where the material in the herbaria in those cities was given due attention. Thus some 225 sheets have been considered in forming the opinions put forth in this paper.

GEOGRAPHICAL DISTRIBUTION

This group is peculiar to the west coast of America, the range generally ascribed to the initial species, *L. microcarpus* Sims, being the range of the entire group. In South America, the plants seem to be confined to central Chile, having an altitudinal distribution from the coast far up into the Andes. In North America the longitudinal range is from Vancouver Island to Lower California;

Vancouver and the adjacent islands have one isolated form, the Yakima Valley in Washington another. This latter, one local form of central Oregon, and one of western Nevada are the only ones peculiar to the country east of the Cascade-Sierra ranges. The more widely distributed form northward is apparently common both to the waterways in Oregon east of the Cascades and also to southwestern Oregon and the northern counties of California. Central California is evidently the center of distribution of the group, and there many specialized and localized forms occur, from the coast well up into the Sierras.

DIAGNOSTIC CHARACTERS

Most of the characters ascribed by Sims and Bentham to their species are common to all members of the group, and cannot be used to distinguish between the two species. Agardh's treatment of the species was mainly based upon the specimens seen by him in Lindley's herbarium. A small-flowered plant collected by Douglas in California, as well as all the Chilean material there, he referred to Sims's species. A more robust and longer-haired plant he accepted as Bentham's *L. densiflorus*, and this he acknowledged as having the aspect and nearly all the characters of *L. microcarpus*,

sed robustior et villo longiore praecepue in partibus floribus obsitus. Ceterum petioli longiores, verticilli densiores floresque albescentes videntur. Unica autem differentia, quae ad speciem distinguendam valere videatur, e bracteis sumenda est.

The yellow-flowered, short-pubescent form with long racemes of distinct verticels was set apart as his *L. Menziesii*. Three certain forms collected by myself in California were very readily determined as these three species of Agardh; but when I considered other forms found by me, the original plates of *L. microcarpus* and *L. densiflorus*, and also the conflicting determinations and opinions of various botanists, it seemed logical to conclude that the group needed special attention.

Upon taking up the study, I soon found that reliable diagnostic characters are not as readily selected as I expected them to be. Many which at first recognition appeared to be all-sufficient for clear-cut distinctions finally suffered complete or partial abandonment after being carefully weighed. As a rule, the general aspect will appeal to the eye first and the general structure of the vege-

tative parts of the plant merits reasonably close attention. Evidently the environment, and especially competition with plants of other genera, has much to do with whether the plant is low or tall. Presumably the amount of available plant food may determine whether the plant is acaulescent and unbranched, or more or less caulescent and branched. The axial terminal bud, unless injured by some external cause, may be depended upon to produce a fruitful peduncle. Branching is, of course, merely the result of the development of axillary buds, and it is common, in large well-branched plants, to find matured or ripened seeds in the pods of this axial peduncle when the racemes of at least some of the branches are still in bloom. A low unbranched acaulescent plant is a record of its own environment, and a dry barren hillside or desert area the habitat in which it is able to both exist and persist. On the other hand, a tall plant, branched more or less above the base perhaps, almost always comes from an environment also favorable to plants of other genera; and abundance of nourishment, assisted by the stimulation of competition, is fundamentally responsible for the extensive vegetative growth developed. The "fistulous" character, especially, is certainly the evidence of a rapid growth during a warm moist season. I see no "specific" characters in the stem structures of these plants, excepting, to some extent, in *L. luteolus* Kell.; but I have admitted into my treatment of varieties more than one definite reference to such stem characters, especially when coupled with other characters or supported by geographical distribution. The length of the petioles and the size of the leaflets and stipules vary with the stem portions and seem to me to be of no value for specific distinctions. Even the pubescence failed to give satisfaction in my effort to draw specific lines.

Most reliable of all, I have concluded, is the position of the flowers in anthesis and soon after anthesis. This may not always be strictly constant in all the flowers of a particular raceme, nor in all the racemes of a certain plant; but I am convinced that, with occasional allowance here for some little variation, this character will prove to be as positive a one as can be found in the *Microcarpi*, and certainly is more usable than the very indefinite distinctions as yet proposed by those who have treated any of the

group. The verticels are regularly crowded in *L. luteolus* and *L. horizontalis*, usually well separated in *L. microcarpus* and *L. subvexus;* but in *L. densiflorus* is found a full range of variations from densely crowded to quite remote. The floral bracts vary much in length, usually becoming reflex-withering as the flower-buds open; but in one variety of *L. subvexus* they are rather conspicuous for their tardiness in reflexing. Their length seems to be too inconstant to be of much diagnostic value.

With few exceptions, I have not been able to accept size and color of petals for specific distinctions, though such are abundantly used in the varietal characterizations. At the free edges above, the keel petals are usually ciliate, often densely so, and a tendency to be ciliate at the free edges below is more or less pronounced in a few of the forms herein designated as varieties; but in *L. luteolus* this ciliation below is as dense and prominent as that above, usually extends backward onto the claws, and seems to be worthy of special notice. Variation in size, shape, apex and base of banner; ciliation, length, and width, but not detailed form, of wings; size, shape, and curvature of keel—are all worthy of consideration in the delineation of varieties. The pubescence of the calyx usually agrees rather closely with that of the peduncles, petioles, etc. The lower lip, I am persuaded, yields good varietal characters as to length, dentation, and inflation; but the upper lip, at least in many cases, varies too much within the flowers of a given raceme to be trusted for any distinctions. The presence or absence of bracteoles is usually a decided uncertainty; but their presence may be diagnostic in *L. horizontalis* and in Elmer's *L. glareosus*.

The size, relative thickness, surface, color, and marking of the seeds—when more of same have been collected and properly identified—will probably be found of value in the varietal, if not in the specific, classification; but in *L. luteolus* again, I find a seed character seemingly distinctive and peculiar to that species. The mature pods show much variation in size, but otherwise give little evidence of deserving much consideration.

PATHOLOGICAL MATERIAL

Abnormal specimens are occasional, and care should be exercised to avoid them in the designation of varieties. Field work

may sometimes be necessary in order to establish that a certain variation is really the result of a diseased condition. Usually, however, an abnormal development is indicated by pronounced elongation or multiplication of some of the floral parts. One very interesting case is that represented by sheet 366288 in the U. S. National Herbarium (*K. Whited 536*, Ellensburg, Washington). In both specimens the flowers dissected have three wing-petals each, and in one all the wing- and keel-petals are very abnormal in shape (FIG. 1). In the case of sheet 620193 (*V. Bailey 91*,

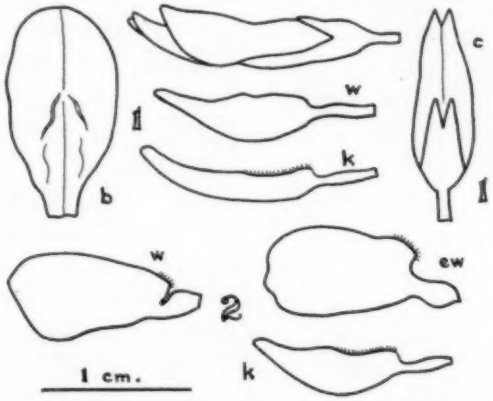

FIG. 1. LUPINUS SUBVEXUS FLUVIATILIS C. P. Smith. *K. Whited 536* (US 366288). 1. From specimen on right. *b*, banner; *w*, wing (three like this); *k*, keel; *c*, calyx as seen from above; side view of entire blossom above. 2. From specimen on left: *w*, wing (two like this); *ew*, extra wing petal; *k*, keel; no banner present.

Toppenish, Washington) the flowers are of the same narrow form and seemingly fruitful.

SPECIAL ABBREVIATIONS

The location of each specimen cited is indicated by an abbreviation. The abbreviations used are as follows:

DS, Dudley Herbarium of Stanford University;
UC, herbarium of the University of California;
ColU, herbarium of Columbia University;
T, Torrey Herbarium (at New York Botanical Garden);
NY, herbarium of the New York Botanical Garden;
G, Gray Herbarium of Harvard University;
US, United States National Herbarium;
PA, Philadelphia Academy of Arts and Sciences;
CPS, private herbarium of the writer.

ILLUSTRATIONS AND MEASUREMENTS

The figures are mere outline representations of the dissected floral parts, mounted in water under cover-glass slips. The calyx is represented as seen from above, the upper lip having been pressed down to show its proportional relations to the lower lip. By this method, the interstitial bracteoles, if present, are not apt to be overlooked. One wing-petal is often added merely to show the extent or absence of the ciliation. The banner is flattened out sufficiently to get the measurements and show the shape of the apex and claw. The measurements, with necessary exception in a very few cases, were made from these dissected floral parts after same had been softened in boiling water and mounted for drawing.

Key to the species of the Microcarpi

Bracts subulate throughout, mostly stiff and not reflex-withering, about 5–6 mm. long, little more than twice the length of the pedicels; flowers 9–11 mm. long. 1. *L. malacophyllus.*

Bracts linear-lanceolate with a dilated thin base, mostly reflex-withering as the flower-buds open, at least the lower much longer than the pedicels; flowers 11–19 mm. long.

Flowers ascending to suberect in anthesis.

Banner 4–6 mm. wide; wings naked below and often above; calyx ebracteolate. 2. *L. microcarpus.*

Banner 7–11 mm. wide; wings and keel ciliate near the claw both below and above; calyx bracteolate. 3. *L. horizontalis.*

Flowers spreading in anthesis.

Flowers soon becoming suberect after anthesis, not secund. 4. *L. subvexus.*

Flowers spreading or distinctly secund after anthesis.

Plants 30–90 cm. tall, strictly fibrous, often widely branched above; banner ovate; keel densely ciliate at base both below and above; verticels crowded; seeds uniformly blackish brown, regularly tuberculate. 5. *L. luteolus.*

Plants 4–50 cm. tall, stems short and fibrous or elongated and fistulous; banner elliptic to oval, rarely ovate; keel usually naked near base below; but sometimes sparsely ciliate; verticels crowded or remote; seeds smooth or irregularly roughened. 6. *L. densiflorus.* *

1. LUPINUS MALACOPHYLLUS Greene, Pittonia 1: 215. 1888.

I quote from the original description as follows:

Annual, erect, a span high, with a few ascending branches from the base; soft throughout, with a long white villous pubescence . . . . racemes verticillate, at

* *L. densiflorus* and its varieties will be discussed in the third paper of this series.

least below, . . . calyx-lips very unequal; the upper short, scarious, slightly notched; lower . . . distinctly 3-toothed: corolla ½ inch long, light blue and dark purple; keel moderately falcate, naked . . . seeds orbicular, white.

Dry hills, near Verdi, Nevada, 2 May, 1888; collected by Mr. C. F. Sonne . . . related to the homely small-flowered *L. pusillus* and *L. brevicaulis*, but with . . . showy verticillate racemes of large flowers, ..."

This species might well be viewed as a connecting link between the *Pusilli* and the *Microcarpi*. Its possession of verticillate flowers is my only excuse for referring to it in this paper. Forms of *L. subvexus transmontanus*, of northern California and Oregon, are the only specimens of the *Microcarpi* that have already been, and may yet be expected to be, confused with *L. malacophyllus*. Seeds in my collection, collected by Heller, from about Reno, are from pale flesh-color to dark reddish.

NEVADA. Without definite locality, *C. L. Anderson* (UC 170306). Ormsby County: Carson City, 1865, *C. L. Anderson* (UC). Washoe County: along track below Verdi, 16 May, 1897, *C. F. Sonne* (UC); same locality, June, 1889 (UC); Reno, 13 May, 1901, *T. W. Cowgill* (UC); seed only, road between Laughten Springs and Reno, 26 July, 1911, *K. Brandegee* (UC).

2a. LUPINUS MICROCARPUS Sims, Bot. Mag. **50**: *pl. 2413*. 1823. [FIGS. 2, 3.]

The original description is as follows:

Lupinus microcarpus; foliis digitatis, calycibus verticillatis in appendiculatis: labio superiore emarginato inferiore bifido ter breviore, leguminibus rhombeis hirsutis dispermis.

Descr. Stem branched. Leaves digitate: leaflets 9–10, lanceolate, hairy on the under surface, smooth on the upper; petioles twice the length of the leaflets, pubescent. Stipules subulate. Peduncle terminal. Flowers blue, in a verticillate spike:whorls six-flowered. Bracts small, hairy. Calyx inappendiculate (unless the bracts, which are distinct from the calyxes, are to be called the appendices) bilabiate; upper lip much the shortest, emarginate; lower lip bifid. Vexillum oblong. Alae equalling the vexillum. Carina monopetalous, sharp-pointed. Anthers 10, five oblong, and five orbicular. Style the length of the stamens. Stigma capitate. Legume small, rhomb-shaped, mucronate by the persistent style, hairy; seeds two, variegated with black lines and dots.

This species of Lupin is a native of Chili. It has not, we believe, been heretofore described; and differs from all the known species by its small two-seeded pods. We regret however that we did not receive these in time enough to be added to the engraving.

Raised from seeds by John Walker, Esq., of Arnos Grove. It flowered in April, and appears to be annual.

Authors generally, following Agardh, seem to have assumed that any and all Chilean specimens are necessarily *L. microcarpus* Sims. One of my early hypotheses was that the Chilean plant ought to be specifically distinct from all the North American forms referred to this species of Sims. As I now see it, however, neither of these assumptions is altogether in agreement with the facts. A new viewpoint is evidently necessary and the conclusions finally accepted by me are: (1) that the strongest specific character possessed by *L. microcarpus* has never been properly recognized; (2) that most of the North American forms regularly, or occasionally, referred here belong rather to two other species; and (3) that both of these "two other species" are likewise represented in Chile. This viewpoint, as I see it, permits a much more satisfactory classification of the forms under consideration.

FIG. 2. LUPINUS MICROCARPUS Sims. Copied from original plate.

The original description serves little more than to indicate the group, of which this species was the first named and described. The illustration (from which FIG. 2 was copied) shows quite plainly, however, that the flowers must have been ascending to suberect in anthesis, a character that, as stated above, my studies have led me to accept as of real diagnostic value. This character, I am persuaded, will be found to persist under cultivation, at least for a few generations. I find, moreover, amongst the very limited array of Chilean material available for my study, specimens which show this character and which certainly, it seems to me, represent much better the form used for the original illustration than the other Chilean specimens referred elsewhere by myself, or the North American specimens referred here by others. It is very probable that the species, as here limited, is a composite of more than one recognizable form; but I await the opportunity to study new and additional material before attempting to do more with the South American varieties.

CHILE. Vicinity of Santiago, springy hillsides, 4500 ft., near Rio Colorado, 21 Jan., 1902, *G. T. Hastings 468*; without definite locality, *C. Gay*, ex Herb. Mus. Paris (G); Coquimbo, July–Aug., 1856, *W. H. Harvey* (G).

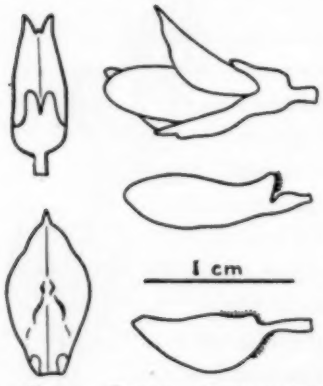

FIG. 3. LUPINUS MICROCARPUS Sims. *G. T. Hastings 468* (UC 65806).

FIG. 3 represents the floral characters of Hastings' No. 468, as recorded above. The specimen may be briefly described as follows: about 15 cm. tall, branches and foliage congested; villous, branched near the base and rebranched above; leaflets about 10–15 mm. long, petioles 50–70 mm. long; flowers ascending to suberect in anthesis; verticels 2–3; legumes 13–15 mm. long, seeds about 5 x 4 mm., straw-colored, unmarked, perhaps immature.

The species is represented in North America by the following variety:

2*b*. **Lupinus microcarpus ruber** (Heller) comb. nov. [FIG. 4.]

Lupinus ruber Heller, Muhlenbergia **2**: 73. 1905.

From Heller I quote:

Branched from the base, the branches diffuse . . . leaflets blue-green . . . smooth above . . . : flowers erect in from 2 to 4 whorls, . . . dull red, 1 cm. long, about 4 mm. across: . . . lower calyx lobe 8 mm. long, barely 3 mm. wide at the base, the apex cleft for 2 mm., with a short cusp in the sinus; upper lip practically obsolete, represented by two short lanceolate teeth of 1 mm.: banner almost plane, ovate-lanceolate, 4 mm. wide at base, slightly keeled; wings narrow, 2 mm. wide, the lower edges not meeting until near the apex; keel not strongly curved, barely 2 mm. wide at the middle, bearded only near the slightly narrowed base. . .

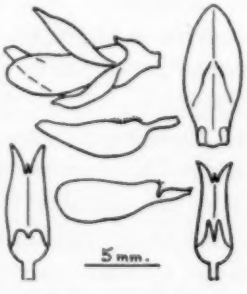

FIG. 4. LUPINUS MICROCARPUS RUBER (Heller) C. P. Smith. *K. Brandegee* (UC 149863).

The type is no 7827, collected May 5, 1905, at Tehachapi, Kern County, California, along the railroad a short distance west of the town. It is a species remarkable for its small narrow red flowers. Some of the specimens show only a short central flowering branch much shorter than the leaves, while others have in addition lateral branches about equalling the leaves. It is a relative of *L. brevicaulis*, but that has "deep blue" flowers, the parts all but the keel differing in shape, and that is glabrous, while in ours it is bearded near the base.

The calyx is mostly 7–9 mm. long, the teeth of the lower lip are about 1.5 mm. long, commonly slender and curved-diverging, and the interstitial "cusp" is conspicuous. The flowers vary from dark red to merely pinkish. The seeds are yellowish gray to flesh-color, about 3.5 mm. x 3 mm., flattish, coarsely rugose, unmarked or nearly so. *L. brevicaulis*, with which Heller compares the plant, is a member of the *Pusilli*.

CALIFORNIA. Kern County: Tehachapi, 5 May, 1905 *A. A. Heller 7827* (US, PA, NY, G); Tehachapi, June, 1911, *K. Brandegee* (UC). San Diego County: Jacumba Hot Springs, near Monument No. 233, 26 May, 1894, *L. Schoemfledt*, U. S. & Mex. Int. Bound. Comm. No. 3307 (US); same locality, 29 May, 1894, *E. A. Mearns*, U. S. & Mex. Int. Bound. Comm. No. 3336 (US); Banner, 25 Mar., 1901, *T. S. Brandegee* (UC); Jacumba, 2500 ft., 9 July, 1916, *E. A. McGregor 88* (CPS). San Bernardino County: Mesas, Argus Mountains, Apr.–Sept., 1897, *C. A. Purpus 5437* (US, G, UC). ?San Luis Obispo County: La Panza, 26 May, 1888, *Mrs. Mathews* (UC).

3*a*. LUPINUS HORIZONTALIS Heller, Muhlenbergia **2**: 74. 1905. [FIG. 5.]

I quote from the original description, as follows:

Branches several, all floriferous . . . the lowest ones horizontal, the ones above them more ascending, the middle ones erect . . . lower lip of calyx green, pubescent with somewhat tangled hairs, ovate-lanceolate, 6 mm. long, over 3 mm. wide at base, barely acutish, the apex minutely 2-toothed; upper lip ovate, membranous, barely 2 mm. long, cleft nearly to the base, the lobes lanceolate with rather wide sinus, villous and ciliate: flowers pale violet-blue, whorled and crowded . . . erect, 1 cm. long, 7 mm. across; banner plane or only slightly turned back, with a prominent midvein; wings . . . 2 mm. wide . . . keel not much curved, ciliate on the lower third . . . seeds nearly 3 mm. across marked with small dark spots.

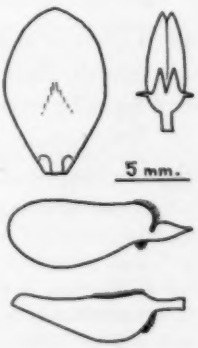

FIG. 5. LUPINUS HORIZONTALIS Heller. *A. A. Heller 7725* (G).

I accept this as a well-marked species. It is probably peculiar to the region of the type locality, though represented southeastward by a distinct variety.

CALIFORNIA. Kern County: Sunset, 20 Apr., 1905, *A. A. Heller 7725* (US, PA, G, NY).

3*b*. **Lupinus horizontalis platypetalus** var. nov. [FIG. 6.]

A *L. horizontali* differt partibus omnibus florum majoribus latioribusque; vexillo 15 x 11 mm., alis 15 x 7 mm., carina 12 x 4 mm.; calyce 9 mm. longo; ramis exterioribus specie non prostratis; seminibus prope 3.5 x 3 mm. crassis.

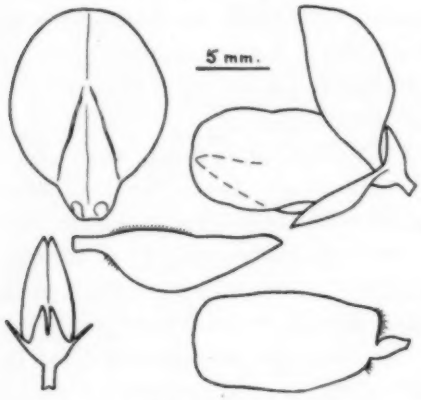

FIG. 6. LUPINUS HORIZONTALIS PLATYPETALUS C. P. Smith. *Hall & Chandler 6860* (UC 127296).

All the floral parts are much larger and broader than in the typical form of the species, and the outer branches are apparently not prostrate. The seeds are of a buff ground, marbled with purplish brown.

CALIFORNIA. San Bernardino County: eastern base of Fremont's Peak, Mojave Desert, 6 May, 1906, *Hall & Chandler 6860* (TYPE, UC 127296); Mojave Desert, May, 1882, *S. B. & W. F.Parish 1271* (G). Kern County: near Randsburg, May, 1913, *K. Brandegee* (UC).

Platypetalus is Greek for "broad petal."

4*a*. LUPINUS SUBVEXUS C. P. Smith, Bull. Torrey Club 44: 405. 1917. [FIG. 7.]

The following is a part of the original description:

Simple or branched, loosely villous, the hairs 2–4 mm. long; whorls 3–7, well- separated; flowers spreading in anthesis, evidently ascending to suberect later; calyx ebracteolate, quite villous below; pods not secund. The typical plant has the lower lip of the calyx evidently inflated (subsaccate) near the base, large flowers with much of the banner and wings dark purple, and the banner rounded apically. Most of the varieties have the lower calyx-lip scarcely or not at all inflated and smaller flowers with the banner gradually narrowed to an acute apex.

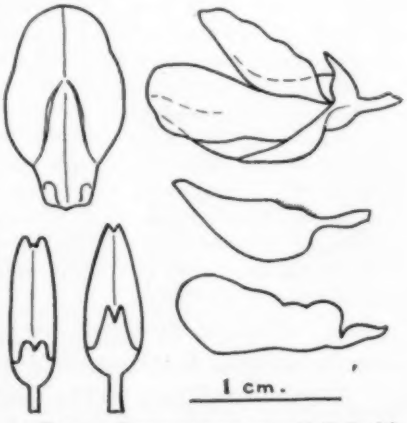

FIG. 7. LUPINUS SUBVEXUS C. P. Smith. *Heller & Brown 5415* (DS 9586).

CALIFORNIA. Yolo County: Madison, *Heller & Brown 5415* (DS, US, PA, NY, G). Contra Costa County: Antioch, 3 May, 1894, *A. Eastwood* (G, UC); Antioch, 8 Apr., 1895, *A. Eastwood* (US); Clayton, 17 Apr., 1889, *Chesnut & Drew* (UC). Alameda County: Oakland Hills, 1866, *H. N. Bolander 100* (G); Alameda, *T. S. Brandegee* (DS 9589); Livermore Pass, May, 1898, *J. B. Davy* (UC); Cedar Mountain, May, 1903, *A. D. E. Elmer 4371* (US, NY). San Francisco County: San Francisco, Apr., 1893, *I. Tidestrom* (UC).

Most, if not all, of these specimens are labeled *L. microcarpus* Sims, though the type sheet bears a correction, by A. A. H., changing the determination to *L. densiflorus* Benth.

Subvexus, "sloping upward," refers to the position assumed by the flowers upon withering.

Key to the varieties of Lupinus subvexus

Calyx 9–11 mm. long.
- Banner truncate, rounded, or obscurely angled at apex, usually 7–8 mm. wide.
  - Bracts normally reflex-withering as the flower-buds open.
    - Flowers 14–17 mm. long; calyx 10–11 mm. long; leaves not blackening in drying. — 4*a*. typical *subvexus*.
    - Flowers about 14 mm. long; calyx 9 mm. long; leaves blackening in drying. — 4*b*. var. *nigrescens*.
  - Bracts tardily or not at all reflex-withering. — 4*c*. var. *fluviatilis*.
- Banner evidently angled at apex, 5–7 mm. wide.
  - Wings usually non-ciliate; keel naked below.
    - Verticels approximate; plants 8–18 cm. tall, bushy. — 4*d*. var. *transmontanus*.
    - Verticels remote; plants 20–40 cm. tall, with stems and branches elongated and fistulous below. — 4*e*. var. *Leibergii*.
  - Wings strongly ciliate near base above; keel ciliate below. — 4*f*. var. *insularis*.

Calyx 7–8 mm. long; banner 5–6 mm. wide, angled at apex.
- Leaflets 20–40 mm. long, 7–10 mm. wide, green; banner 9–11 mm. long.
  - Verticels distinct; keel straight. — 4*g*. var. *phoeniceus*.
  - Verticels crowded; keel evidently arcuate. — 4*i*. var. *Wilkesii*.
- Leaflets 10–20 mm. long, 4–6 mm. wide, conspicuously white woolly-villous; banner more slender, 12–14 mm. long. — 4*h*. var. *albilanatus*.

4*b*. **Lupinus subvexus nigrescens** var. nov. [FIG. 8.]

A *L. subvexo* typico differt foliolis nigrescentibus cum siccantes; pilis brevioribus inconspicuuis; floribus paulo minoribus; labio inferiore calycis vix inflato; alis superne ad basin ciliatis.

Differs from the typical form in that the leaflets turn black in drying, hair-covering less conspicuous, flowers smaller, lower lip of the calyx but slightly subsaccate, and the wings ciliate above near the base.

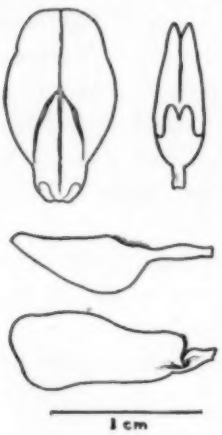

FIG. 8. LUPINUS SUBVEXUS NIGRESCENS C. P. Smith. *A. D. E. Elmer 4006* (US466205).

CALIFORNIA. Ventura County: Griffins, Mt. Pinos, July, 1902, *A. D. E. Elmer 4006* (TYPE, US 466205; type-duplicates, DS, NY). Kern County: hills, near the summit of Tejon Pass, on desert slope, 27 May, 1914, *S. B. Parish 9256* (UC).

This variety merits special study in the field, with collection of considerably more material. It is very different from Elmer's *L. glareosus*, taken at the same locality, but shares with that variety the peculiar character of the leaflets turning black in drying. The specimens are labeled *L. microcarpus*.

4*c*. **Lupinus subvexus fluviatilis** var. nov. [Fig. 9.]

Eramosus vel ramosus ad basin ramis suberectis vel pandentibus, 10–25 cm. altus, conspicue villosus; foliis paulo congestis

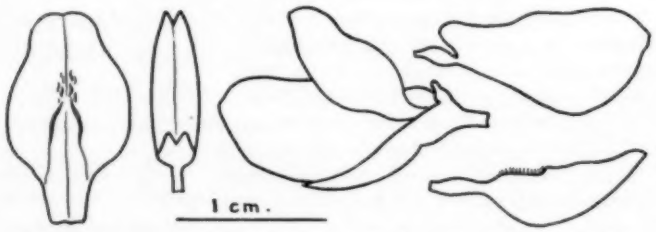

FIG. 9. LUPINUS SUBVEXUS FLUVIATILIS C. P. Smith. Fritillaria Club (US 205559).

cum planta humilis eramosaque est, plus patentibus cum planta ramosa est; pilis 1–1.5 mm. longis; petiolis 4–10 cm. longis, villosis, pilis saepe paulo plus 2 mm. longis; foliolis 5–10, 15–25 mm. longis, saepe obovatis vel spatulatis nonnumquam oblanceolatis, apice rotundatis vel angulatis, ciliato-villosis ad medio-costis marginibusque: pedunculis foliis plerumque brevibus; verticillis 3–5, plus minusve appositis; floris ad anthesin pandentibus, postea ascendentibus vel suberectis, 14–16 mm. longis; pedicellis paulo plus 1 mm. longis, plurimum gracilibus; bracteis verticilli humillimi calyce prope aequantibus longitudine, tarde vel nequaquam

reflectentibus et marescentibus, laxe villosis vel sublaevibus: calyce ebracteolato 9–10 mm. longo, subter dense villoso pilis prope 2 mm. longis, labio superiore diverso 2-dentato, prope 2 mm. longo, inferiore subrecto vel ad basin paulo inflato 3 mm. lato 2-dentato, sinu plerumque sine vestigio; corolla pallido-rosea vel-purpurea; vexillo 12–14 mm. longo, 7–8 mm. lato, apice paulo contracto, rotundato vel truncato, plus contracto ungue 2–4 mm. lato; alis 11–14 mm. longis, 5–7 mm. latis, ad basin non ciliatis; carina 9–11 mm. longa, subrecta: leguminibus usitatibus prope 14 x 8 mm.; seminibus pallidis maculatis, 4.5 x 4 mm.

WASHINGTON. Without definite locality, 1889, *G. R. Vasey 259* (TYPE, US 296664; type-duplicates, G, NY). Yakima County: Yakima region, 1882, *T. S. Brandegee 42* (UC); North Yakima, Oct., 1885, *T. S. Brandegee* (UC); Fritillaria Club, North Yakima, 1890, (US); Toppenish, 17 July, 1897, *V. Bailey 91* (US); Yakima, 3 June, 1898, *A. B. Leckenby* (US); North Yakima, 29 May, 1899, *J. B. Flett* (US); Wenas, 1 June, 1902, *Griffith & Cotton 85* (US, NY). Kittitas County: Ellensburg, 25 June, 1897, *K. Whited 536* (US); Ellensburg, June, 1897, *A. D. E. Elmer 371* (US, NY).

Seemingly peculiar to the valley of the Yakima River in central Washington. The flowers are relatively large with broad petals. Perhaps the strongest individual character is that the floral bracts are tardily or not at all reflex-withering as the flower-buds open. The seeds are flesh-color, mottled with a pale reddish brown, the hilum of the darker color. FIG. 1 illustrates abnormal specimens of this variety.

Fluviatilis is Latin for "of a river," and refers to the habitat.

4*d*. **Lupinus subvexus transmontanus** var. nov. [FIG. 10.]

A var. *fluviatili* differt foliolis oblanceolatis plerumque acutis; calyce 9–11 mm. longo, sinu labii inferioris plerumque dentis vestigio instructo; vexillo apice angulato, 11–12 mm. longo, prope 6 mm. lato ad basin paullatim contracto.

Similar to var. *fluviatilis*, but the leaflets are usually acute at the apex, the floral bracts usually reflex and wither as the flower-buds open, the lower lip of the calyx has the vestigial median tooth, and the banner is evidently acute at the apex.

OREGON. Wasco County: Antelope, May, 1885, *T. Howell* (TYPE, US 20844; type-duplicate, PA). County not given: Currant Creek, 11 May, 1885, *T. Howell 361* (G); John Day River, Crown Rock, 19 June, 1896, *V. Bailey 65* (US). Malheur County:

Malheur River, June, 1883, *Cusick 1113* (G). Jackson County: Antelope Creek, near Eagle, 4 June, 1898, *E. I. Applegate 2388* (US).

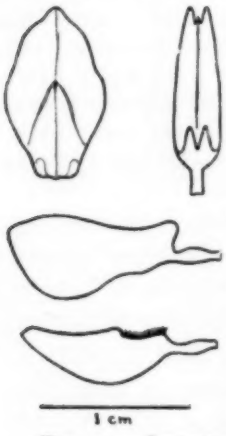

FIG. 10. LUPINUS SUBVEXUS TRANSMONTANUS C. P. Smith. *T. Howell* (US 20844).

CALIFORNIA. Modoc County: meadow bank along stream, 28 July, 1893, *Milo S. Baker* (UC); shore of Goose Lake, Aug., 1895, *Mrs. R. M. Austin* (US); sagebrush at Tule Lake, 31 May, 1897, *E. I. Applegate 879* (US); Goose Lake, July, 1898, *Mrs. R. M. Austin & Bruce 154* (UC). Lassen County: Craigs, 1893, *M. S. Baker* (UC); Madeline Plains, June, 1898, *Mrs. R. M. Austin & Bruce 2145* (DS, NY, UC). Siskiyou County: Klamathon, 2 July, 1903, *E. B. Copeland*, Baker Distribution 3537 (US, NY, G); Klamath Hills, 13 May, 1909, *G. D. Butler 704* (UC); Klamath Hills, 21 May, 1910, *G. D. Butler 1373* (US, UC).

Transmontanus is Latin for "across the mountains" and refers to the fact that the form is found on both sides of the Cascade ranges. It has been determined as *L. densiflorus*, *L. microcarpus*, and *L. malacophyllus*.

4*e*. **Lupinus subvexus Leibergii** var. nov. [FIG. 11.]

A var. *transmontano* differt altitudine 25–40 cm.; caule fistuloso ramoso aliquantum super basin; pedunculis ramisque elongatis: verticillis 4–5, distantibus; floribus suberectis mox post anthesin prope 13 mm. longis: bracteis mox marescentibus; calyce 2-dentato, 10 mm. longo, prope 3 mm. lato; vexillo 11 mm. longo, 5 mm. lato, apice acuto vel prope acuminato, ungue 4 mm. lato basi; alis 11 mm. longis; carina 8 mm. longa, recta.

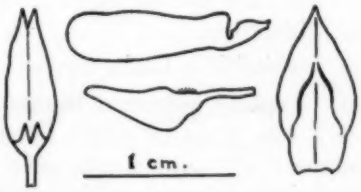

FIG. 11. LUPINUS SUBVEXUS LEIBERGII C. P. Smith. *J. B. Leiberg 317* (US 291134).

Unlike the other northern races of *L. subvexus*, this variety is branched from well above the base and has the lower parts distinctly fistulous. The verticils are remote, the banner is almost acuminate at the apex and its claw is poorly defined, and the

flowers are evidently far from being showy. It is probably very local and rare and should be carefully studied in the field.

OREGON. Crook County: near Prineville, 955 m. alt., 1894, *J. B. Leiberg 317* (TYPE, US 291134; type-duplicates, G, US 291133).

4*f*. **Lupinus subvexus insularis** var. nov. [FIG. 12.]

Ad basin ramosus; foliis aliquantum congestis, foliolis gracilibus 2–3 cm. longis; racemis pluribus, floribus ad anthesin pandentibus ascendentibus postea, bracteis reflectentibus, bracteis petiolis pedicellisque laxe villosis; calyce dense villoso; carina curva.

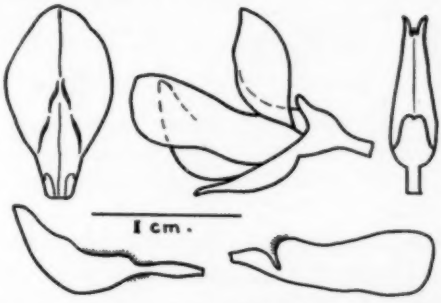

FIG. 12. LUPINUS SUBVEXUS INSULARIS C. P. Smith. *T. S. Brandegee* (UC 82003).

Much branched near the base, foliage congested, leaflets slender and 2–3 cm. long; racemes several with the flowers spreading in anthesis but ascending soon afterwards, bracts reflexing as the flower-buds open, the bracts, petioles and pedicels loosely villous; calyx densely villous; keel distinctly curved.

CALIFORNIA. Santa Cruz Island: Apr., 1888, *T. S. Brandegee* (TYPE, UC 82003).

Mounted on the sheet with the above specimen are some small plants (UC 82002) collected by Brandegee at San Telmo, Lower California, 28 Apr., 1893. These may represent the variety *insularis*, but should prove to be different. They are so small and in such condition I prefer to attempt no definite classification of them at this time.

4*g*. **Lupinus subvexus phoeniceus** var. nov. [FIG. 13.]

Eramosus vel ad basin laxe ramosus, ramis ramulosis laxe breve-villosis: verticillis 2–5 vel plus, appositis vel distantibus; floribus ad anthesin pandentibus, postea ascendentibus vel suberectis, 12 mm. longis; calyce ebracteolato, 7 mm. longo, subter paulo

laxe villoso, pilis 1–1.5 mm. longis, paulo retrorsis, labio superiore minus 2 mm. longo, inferiore lanceolato-oblongo, vix 3 mm. lato, 2-dentato dentibus 1 mm. longis parallelis plerumque dentis vestigio instructo; corolla phoenicea vel pallidiora; vexillo 10–11 mm. longo, 6 mm. lato, apice angulato; alis 9 mm. longis ad basin superne paulo ciliatis; carina 8 mm. longa, plerumque recta: legu-

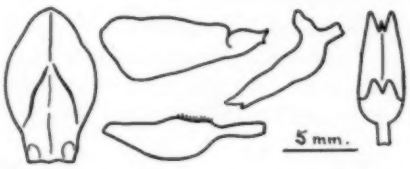

FIG. 13. LUPINUS SUBVEXUS PHOENICEUS C. P. Smith. *A. A. Heller 8632* (US 612641).

minibus 13 x 7 mm.; seminibus planis angulatis, 5 mm. longis, 4 mm. latis, atro-cineraceis, minute nigromaculatis circum cicatricula pallidioribus, superficie minute inaequaliterque rugoso simile quartzo.

Simple or loosely branched from near the base, loosely short villous; whorls usually two to five, crowded or distinct; flowers spreading in anthesis, soon becoming suberect, about 12 mm. long; calyx retrorse-villous below with hairs 1–1.5 mm. long, the lower lip with a vestigial median tooth; petals reddish purple or paler, the banner about 10 x 6 mm., angled at the apex; seeds 5 x 4 mm., somewhat flattened and angled, dark-gray, minutely dotted with black, paler about the hilum, the entire surface minutely roughened, resembling quartz.

CALIFORNIA. Santa Clara County: Mt. Hamilton road, 2300 ft. alt., "on a roadside bank near oak trees," 31 May, 1907, *A. A. Heller 8652* (TYPE, US 612641; type-duplicates, PA, NY, G); seed only, type locality proper, 17 June, 1908, *C. P. Smith* (CPS); tilled soil below Smith Creek bridge, 17 June, 1908, *C. P. Smith 1479;* Calaveras Valley, May, 1914, *K. Brandegee* (UC 178195, except as to raceme in upper left hand corner).

This seemingly well-marked variety may be peculiar to the Mt. Hamilton Range. The plants are low and mainly simple in poor soil, but in richer and looser soil may be 2–3 dm. tall with a spread of 3–4 dm. The Smith Creek specimens were in seed as to the primary branches, while secondary branches, in the axils of the primary branches, were in flower.

Probably related to this, but certainly not typical, are the following: Atascadero, San Luis Obispo County, 30 Apr., 1861, *W. H. Brewer 493* (US); Ojai and vicinity, Ventura County, 24 May, 1866, *Peckham* (US). Additional material from these localities would be welcome and worthy of careful study.

The type collection has been recorded as *L. microcarpus* by Heller (Muhlenbergia **2**: 294. 1907).

Phoeniceus is Latin for "purple-red."

4*h*. **Lupinus subvexus albilanatus** var. nov. [FIG. 14.]

A var. *phoeniceo* differt foliis gracillimis acutis plurimum solum 10–20 mm. longis; foliis petiolis pedunculisque conspicue brevilanato-villosis; vexillo 12–14 mm. longo, graciliore; seminibus plurimum minoribus pallidioribus, immaculatis vel maculatis.

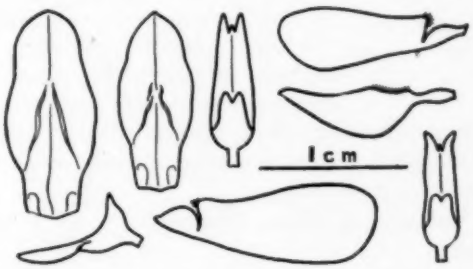

FIG. 14. LUPINUS SUBVEXUS ALBILANATUS C. P. Smith. *K. Brandegee* (UC 149886).

CALIFORNIA. San Luis Obispo County: Paso Robles, July, 1911, *K. Brandegee* (TYPE, UC 149886; type-duplicates, UC 149884, 149885, and 149947). Monterey County: near Plaskett's ranch, on road to Jolon, about seven miles from Kings City, *K. Brandegee* (UC); Manfield's ranch, Santa Lucia Mountains, ten miles from Kings City, 1–12 May, 1897, *A. Eastwood* (G).

This variety is conspicuous for its whitish cast and the narrowness of its banner. The seeds are variable in size and color, as shown by Mrs. Brandegee's collections. Those with sheet 149884 are about 5 x 4 mm., some milky- or bluish-white unmarked with the hilum area flesh-color, while others are drab with an occasional dark speck and a conspicuous bluish-white or pale area about the scar. Those with sheet 149885 are 4 x 3 mm. with a drab ground much speckled with black, the hilum area little or conspicuously paler and unspotted. Those with sheet 125917

(Monterey County) are 4 x 3 mm., heavily marbled with dark-brown, the hilum area unmarked and pale. The variety is evidently confined to the upper Salinas Valley.

Albilanatus is Latin for "white-woolly," which is descriptive of the general pubescence in this plant.

4*i*. **Lupinus subvexus Wilkesii** var. nov. [FIG. 15.]

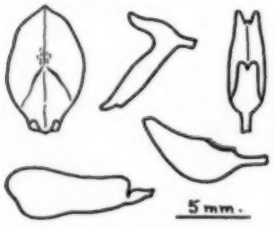

FIG. 15. LUPINUS SUBVEXUS WILKESII C. P. Smith. *Capt. Wilkes* (US 20841).

A var. *phoeniceo* differt verticillis confertis et carina curva: caulo plus minusve erecto, 20–30 cm. alto, gracili aliquantum super basin ramoso, laxe villoso pilis 1 mm. longis; petiolis gracillimis 5–8 cm. longis; foliolis 7–9, oblanceolato-spatulatis prope 15 mm. longis; pedunculis folia aequantibus, laxe villosis; verticillis prope 8, inferioribus distantibus, superioribus confertis; floribus 9–10 mm. longis ad anthesin pandentibus mox postea suberectis; pedicellis gracillimis; bracteis prope 5 mm. longis mox reflectentibus; calyce 7–8 mm. longo, labio inferiore 2-dentato, sinu dentis vestigio instructo: legumina et semina non vidi.

CHILE. Valparaiso, *Capt. Wilkes*, U. S. Explor. Exped. (TYPE, US 20841).

The specimen is labelled "*L. microcarpus*, var.," but is so different from all other Chilean material seen by me that I think it best to set it apart as a variety of *L. subvexus*. The flowers become suberect soon after anthesis and have several characters in common with var. *phoeniceus*, but this differs in the greater number of whorls, more crowded above, in the very slender pedicels, and in the curved keel.

5. LUPINUS LUTEOLUS Kell. Proc. Cal. Acad. Sci. **5**: 38. 1873. [FIG. 16.]

Lupinus Bridgesii Gray; Watson, Proc. Am. Acad. **8**: 538. 1873.

From Kellogg's description I quote:

Stem 1–2 feet high, suffruticose, glabrous below, bark light creamy hue, satiny fibrous; numerously branched toward the top, forming a very symmetrical rather wheel-shaped cone. . . . Leaflets . . . silky above and below. . . . Flowers light yellow . . . in a dense crowded spike 6 to 12 inches in length . . . calyx tube scarious, very short and widely gaping, 2-bracteolate . . . upper lip ovate-lanceolate, acute, entire; lower lip herbaceous, 3-toothed, slightly deflexed and subsaccate at the junction of the scarious portion . . . wings broad and somewhat inflated, glabrous, with scarcely

a few hairs on the margin at the base; keel acute, villous on the margins above at the lower third. . . .

Found on the Coast range of mountains, near Senal, Mendocino County, Cal. 1872.

From Watson I quote:

Stem 1–2 feet high . . . leaflets . . . pubescent both sides or somewhat smooth above . . . petals pale yellow. . . .

Sacramento Valley. Collected by Bridges (55), Bolander (6512), and Dr. Kellogg.

Jepson (Fl. West. Mid. Cal. 2d ed. 216. 1911) emphasizes the "herbaceous" character of the upper calyx-lip.

As shown by my drawings, I have made studies of dissected flowers from specimens taken at five different stations, representing the geographical range of the species. I also studied with

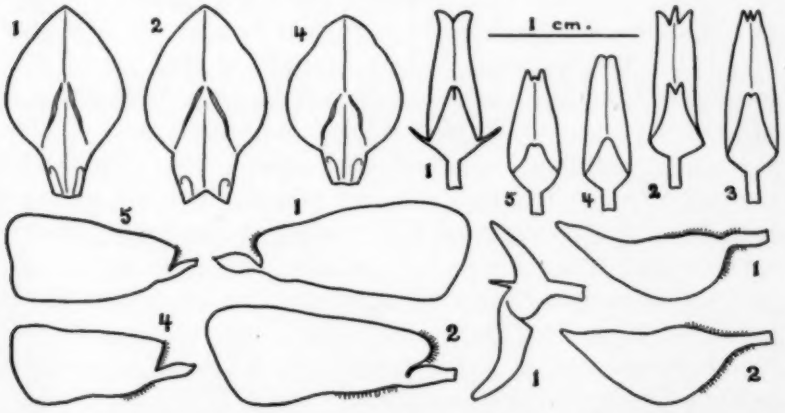

FIG. 16. LUPINUS LUTEOLUS Kell. 1. *A. Eastwood*, Mendocino County (US 468711); 2. *H. N. Bolander* 6512 (US 321126); 3. *F. P. Nutting*, Contra Costa County (UC 15918); 4. *J. P. Tracy* 3496, Humboldt County (US 542773); 5. *M. W. Gorman* 411, Oregon (US 280475).

a lens several others of the specimens listed below. Only one specimen evidently supports the claim for an herbaceous upper lip, and just three sheets plainly show bracteoles present. The banner is usually ovate, acute, with the claw distinct and stiffened. The wings are sometimes strongly ciliate at the base below, as well as above, and the keel seems to be generally as densely ciliate below as above, the ciliation extending well out onto the slender claw. The upper lip of the calyx is sometimes emarginate and

the lower lip is sometimes two-toothed. The seeds are about 4 x 3.5 mm., uniformly dark brown, regularly and roughly tuberculate as to the specimens seen.

CALIFORNIA. County not given: *Bridges 55* (T); 1866, *H. N. Bolander 6512* (US); head of Penn Creek, 5100 ft., Aug., 1875, *J. T. Rothrock 224* (US); near Cheswick, 30 July, 1899, *J. B. Leiberg 4318* (US). Contra Costa County: Fish Ranch, 29 June, 1893, *F. P. Nutting* (UC); Walnut Creek, 28 July, 1897, *Mrs. T. J. Maynard* (UC). Lake County: Lakeport, 16 Aug., 1882, *C. G. Pringle* (US); Allen's Spring, 6 July, 1882, *D. Cleveland* (UC); between Potter Valley and Hullville, 21 July, 1902, *A. A. Heller 5938* (US, CPS); Scott Valley, 21 Aug., 1905, *J. P. Tracy 2372* (UC); Kelseyville, 2 July, 1911, *K. Brandegee* (UC); Kelseyville, July–Aug., 1892, *W. L. Jepson* (UC); between Houghs and Bartlett Springs, 11 Aug., 1910, *K. Brandegee* (UC); Sanhedrin, June, 1894, *Purpus 1132* (UC); Mt. Sanhedrin, 18 July, 1913, *H. M. Hall 9514* (UC). Mendocino County: Covelo, 20 July–3 Aug., 1897, *V. K. Chesnut 543* (US); Cloverdale, Russian River, 9 July, 1902, *A. A. Heller 5830* (US); Calito, 5 Aug., 1902, *A. Eastwood* (US). Humboldt County: valley of Trinity River, near mouth of Willow Creek, 10 July, 1911, *J. P. Tracy 3496* (US); valley of Van Duzen River, opposite Buck Mountain, 27 June–30 July, 1908, *J. P. Tracy 2696* (US, UC); Kneeland Prairie, 26 July, 1912, *J. P. Tracy 3871* (UC); Eel River, July, 1894, *Purpus 1206* (UC). Shasta County: near Middle Creek station, 3 June, 1905, *A. A. Heller 7951* (US). Siskiyou County: Klamathon, 2 July, 1903, *E. B. Copeland*, Baker Distribution 3535 (US); Yreka, 8 June, 1905, *A. A. Heller 7990* (US); Hornbrook, July, 1887, *K. Brandegee* (UC); dry land near Yreka, June, 1908, 1909, 1910, *Butler 375, 910, 1447* (UC).

OREGON. Jackson County: Rogue River Valley, 14 July, 1887, *T. Howell* (UC); Ash Creek, near Ashland, July, 1893, *Mrs. R. M. Austin* (UC); Ash Creek, Rogue River Valley, July, 1893, *Mrs. Austin* (UC); Medford, 25 Aug., 1897, *Mrs. Austin 1651* (US); Spouting Springs, thirteen miles south of Ashland, 13 Aug., 1896, *M. W. Gorman 411* (US). County not given: Dead Indian road, western slope Cascades, 12 Aug., 1902, *W. C. Cusick 2945* (US).

COLLEGE PARK,
MARYLAND

The plant population of northern lower Michigan and its environment

ROLAND M. HARPER

(WITH THREE TEXT FIGURES)

Introduction.—The northern third of the Lower Peninsula of Michigan, an area of about 11,000 square miles, seems to differ from all other parts of the United States sufficiently to be treated as a distinct geographical region. Its most striking characteristic is probably the prevailing sandiness of the soils. (In this particular, as well as in the abundance of lakes, swamps and bogs, it reminds one strongly of Florida.) It differs further from the Upper Peninsula, the nearest land to the northward, in being warmer and therefore in having less of the boreal conifer element in its forests, and from the territory adjoining it on the south in being colder and in having a somewhat different seasonal distribution of rainfall (as will be pointed out farther on) and more swamps.

The southern boundary is very indefinite, but may be located arbitrarily for statistical purposes at the parallel of latitude 44° 15′, which crosses the state from near the mouth of the Manistee River to the mouth of Saginaw Bay, and passes through or near Manistee, Cadillac, and Tawas City. Only about one sixth of the area is under cultivation, so that there is no lack of vegetation to study. But as the lumbermen spoiled the looks of the country before there were many botanists in Michigan, and nearly all the plants happen to belong to widely distributed species, comparatively few botanical explorers have investigated this region. Aside from incidental references in Cowles's well-known monograph on the dunes of Lake Michigan (1899), Beal's Michigan Flora (1904), and a few local plant lists, the following seem to be about the only easily accessible papers on this region that a phytogeographer would need to consult. Some of them contain references to earlier literature of some importance. The arrangement is chronological.

V. M. Spalding. "The Plains" of Michigan. Am. Nat. **17**: 249–259. 1883.
C. S. Sargent. (Forests of) Michigan. Tenth Census U. S. **9**: 550–554. 1884.

R. C. Kedzie. The jack pine plains. Mich. Exp. Sta. Bull. 37. 8 pp. 1888.

S. M. Coulter. An ecological comparison of some typical swamp areas. Rep. Mo. Bot. Gard. **15**: 38–71. *pl. 1–24.* 1904. (See pp. 41–49 for Michigan.)

B. E. Livingston. The relation of soils to natural vegetation in Roscommon and Crawford Counties, Michigan. Bot. Gaz. **39**: 22–41, with map. Jan. 1905. Also in Rep. Mich. Geol. Surv. **1903**: 9–30. *pl. 3.*

H. H. Rusby. Observations in economic botany at Oscoda, Michigan. Jour. N. Y. Bot. Gard. **7**: 211–213. Sept. 1906.

W. J. Geib. Soil survey of Wexford County, Michigan. Field Operations U. S. Bur. Soils **1908**: 1051–1066. 1911. (Advance copies, separately paged, distributed in October, 1909.)

E. S. Whitaker. A vacation in northern Michigan. Forest & Stream **77**: 806–807. Dec. 2, 1911.

Hu Maxwell. Wood-using industries of Michigan. (State publication, no series or number.) 101 pp., 2 folded tables. Lansing, 1912. (The notes on this region are mostly on pp. 7–10. See criticism in Proc. Soc. Am. Foresters **11**: 350. 1916.)

Frank Leverett. Surface geology and agricultural conditions of the southern peninsula of Michigan. (With a chapter on climate by C. F. Schneider.) Mich. Geol. & Biol. Surv. Publ. 9 (Geol. Series 7). 144 pp., 15 plates (including 3 folded maps), 16 figs. 1912.

F. C. Gates. The vegetation of the region in the vicinity of Douglas Lake, Cheboygan County, Michigan, 1911. Rep. Mich. Acad. Sci. **14**: 46–106, with 24 half-tones on 17 plates. 1913.

H. A. Gleason & F. T. McFarland. The introduced vegetation in the vicinity of Douglas Lake, Michigan. Bull. Torrey Club **41**: 511–521. Oct. 1914.

F. C. Gates. The relation between evaporation and plant succession in a given area. Am. Jour. Bot. **4**: 161–178. *f. 1–9* (including 5 half-tones). March, 1917. (Area treated is in Cheboygan County, Michigan.)

H. A. Gleason. Some effects of excessive heat in northern Michigan. Torreya **17**; 176–178. Oct. 1917.

The plant population statistics given below are based on notes taken by the writer while occupying the post of research assistant in botany at the Biological Station of the University of Michigan in the summer of 1912. Most of the observations were made while walking out in all directions from the station (which is on Douglas Lake), as far as Cheboygan and Topinabee on the east and Pellston on the west. Copious notes were also taken from trains on the Michigan Central R. R. from Cheboygan to Mackinaw City, on the Grand Rapids & Indiana Ry. from Cadillac and Mackinaw City to Pellston, and on the Pere Marquette R. R. from Petoskey southward to the limits of the region and beyond.

Geology and soils.—The whole of lower Michigan is underlaid by nearly horizontal Paleozoic strata, largely limestones and shales of Devonian and Carboniferous age, but in the region under

consideration these are exposed only in limited areas near the Great Lakes, and have little influence on soil or topography. The interior is covered by glacial drift, averaging several hundred feet thick and composed of sand, clay, pebbles and small boulders in various proportions. The pebbles and boulders are quite diverse lithologically, but most of them are more or less calcareous. Few of the boulders are more than a foot or two in diameter, or large enough to support any characteristic vegetation.

There is only one government soil survey for this region as yet, and that is for one of the counties at its southern edge. But Leverett's bulletin, above cited, divides the soils of the Lower Peninsula into about half a dozen classes, and gives the approximate acreage of each in every township and county. From the returns from the twenty-one northernmost counties the following percentages have been computed; and the corresponding figures for the remaining forty-seven counties are given in an adjacent column for purposes of comparison.

Soil classes	Northern counties	Central and southern counties
Sandy till	26.9	21.0
Sand	25.9	24.7
Clayey till	18.6	38.2
Swamps and lakes	17.9	8.8
Gravelly loam	9.7	6.7
Gravel	1.0	0.5

The clayey till includes both moraines and glacial-lake deposits, which could have been separated if it had seemed worth while. (The latter type in Michigan is chiefly confined to the vicinity of Saginaw Bay and Lake Erie, and is very sparingly represented in the region under consideration). Some of the larger interior lakes are excluded from the estimate for swamps and lakes.

The sand on many of the uplands is so deep and loose as to make walking and hauling on unimproved roads somewhat difficult in dry weather, just as in many parts of Florida. No satisfactory chemical analyses of the soils seem to be available, but they are doubtless below the average in fertility.

Topography and hydrography.—The topography is that common to many glaciated regions, undulating to hilly, with numerous depressions containing lakes, ponds, swamps, bogs, marshes, etc. The largest lakes cover about thirty-five square miles. The highest

elevations are only about nine hundred feet above the Great Lakes, and are near the southern edge of the region, so that there are probably no differences in vegetation that can be ascribed to altitude alone. Several series of supposed ancient beaches, formed in glacial times when the Great Lakes were considerably higher than at present, have been traced by Leverett and others, but as in the case of the supposed marine Pleistocene terraces of Maryland and other Atlantic states,* these episodes of geological history seem to bear no obvious relation to the present vegetation, except as they may have locally influenced soil or topography. (In other words, the vegetation of an area that has been above the water say a hundred thousand years does not differ noticeably from that of one only ten thousand years old, if the soil is the same. And if the soil is not the same, that is a matter for the geologist to explain, not for the botanist.)

Being on a peninsula not exceeding a hundred and fifty miles in width, this region has no large rivers. The drainage area of the largest, the Cheboygan, covers about sixteen hundred square miles. On account of the absence of rock ledges there are no waterfalls, but in descending a few hundred feet from their sources to their mouths the rivers necessarily traverse some gravelly rapids, which are being utilized more and more for water-power. The presence of many lakes and swamps and the coincidence of the hottest season with the season of greatest precipitation makes the flow of all the streams pretty steady, and on account of the prevailing sandy soil and the scarcity of cultivated fields they carry very little sediment. (In these respects also this region resembles Florida more than it does most of the intervening states.)

Climate.—The average temperature is 41°–45° F., the January mean 18°–23°, and the July mean 66°–69°. The proximity of two of the Great Lakes presumably makes the difference between summer and winter climate a little less than it would be otherwise. The average growing season or period free from killing frosts is 125 to 145 days, the average annual snowfall about seventy inches, and the absolute minimum temperature about —40° F.

This is one of the driest parts of the eastern United States, having only about thirty inches of rain and melted snow annually.

* See Geog. Review 4: 224–225. Sept. 1917.

An interesting feature of the precipitation is that late summer is the wettest season, by a small margin. In this particular our region resembles the pine-barren portions of the coastal plain, and differs notably from southern Michigan and the whole Mississippi valley, where spring and early summer are the rainy seasons. Coming as it does just when the evaporating power of the sun tends to be greatest, the late summer rain helps keep the ground-water level constant and favors the formation of peat. It may be a mere coincidence that two such sandy and peaty and "piney" and thinly settled regions as northern Michigan and peninsular Florida should both have a late summer rainy season, but it is more than likely that the rainfall has influenced the soil somewhat, or even *vice versa* through the vegetation, for there is no apparent physiographic reason why the seasonal distribution of rain should be any different in Michigan from what it is in Ohio and Indiana, for example.

Vegetation.—The aspects of the vegetation or the composition of the plant associations have been described at considerable length in some of the papers cited, particularly those by Livingston and Gates (and Gates's are illustrated), so that it is not necessary to say much more on the subject here, except for pointing out some fundamental principles often overlooked, and giving quantitative data, which have not been supplied before except for very small areas or for only a few species.

The dry uplands have vegetation of three principal types, correlated with soil differences. On the more clayey soils the original forests evidently were mainly of hardwoods and hemlock, making a dense shade and considerable humus. On the most sterile sands forests of jack pine prevail,* while in intermediate habitats, covering most of the upland area, white and red pines seem to have been the dominant trees before the lumbermen appeared on the scene.

The streams have more or less meadow and river-bank vegetation along them, but few species seem to be confined to such situations in the region under consideration. Flat areas adjacent

* See Spalding's paper on "The Plains" previously referred to, and Beal's Michigan Flora, pp. 16–18. The jack pine, *Pinus Banksiana*, resembles the Florida spruce pine, *P. clausa*, very much in general appearance, habitat, and relations to fire. (See Ann. Rep. Fla. Geol. Surv. 7: 142–144, 155. 1915.)

to streams and lakes, with a slow circulation of water through the muck or peat, are generally densely wooded with spindle-shaped, short-leaved conifers of the type characteristic of snowy climates.*

FIG. 1. Peat bog in a small sandy depression close to south shore of Douglas Lake, but apparently quite independent of the lake. Water deep and cool and not subject to much fluctuation. The floating leaves are *Nymphaea variegata*. Bog vegetation of the common slow-growing "high moor" or muskeg type, or the *Chamaedaphne* association of Gates (1913, p. 57); mostly evergreen. The trees are *Picea mariana* and *Larix*, and the shrubs mostly *Chamaedaphne*, *Nemopanthes*, *Andromeda*, and *Kalmia polifolia*. Herbs are relatively inconspicuous, but there is an abundance of sphagnum. (This is one of the few known localities in Michigan for *Razoumofskya pusilla*, which is parasitic on the spruces.)

The basin-like depressions, which may or may not have visible outlets, have quite a variety of vegetation, depending on their size, depth, etc. The larger ones contain lakes, with little vegetation in their deeper parts, many characteristic aquatics in sheltered shallow bays, and still other species, mainly of rush-like aspect, on wave-washed sandy beaches. Around the lakes are also numerous lagoons cut off by barrier beaches, and these commonly contain marsh vegetation, composed largely of grasses, sedges and rushes. The isolated depressions which are too small for wave action are usually occupied, at least around their edges,

* See Pop. Sci. Monthly **85**: 340–341. 1914.

by either marsh or bog vegetation (corresponding to Warming's "low moor" and "high moor" respectively.*)

The most significant difference between marsh and bog vegetation (and one apparently overlooked by Warming in contrasting his low and high moors) is in the rate of growth; and just why rank grasses should occupy one pond and the slow-growing sphagnum, evergreen shrubs, and stunted conifers another has never been fully explained. The depth of the water undoubtedly has a great deal to do with it, for a shallow pond is quickly warmed by

FIG. 2. Looking north across a shallow marsh or sedgy pond, with stagnant water quite warm in summer, a sort of "low moor", 20–25 acres in extent, about 2 miles southeast of Douglas Lake. Vegetation mostly *Carex filiformis*, with a few island-like patches of *Chamaedaphne* and *Andromeda*. Partly burned conifer swamp in background. (A little to the left of this view, near a moderately rich hillside, was some ranker and therefore faster-growing vegetation, including *Calamagrostis canadensis*, *Typa latifolia*, *Sparganium*, and *Iris versicolor*.)

the sun, and one in Michigan, where the sun shines nearly sixteen hours a day in midsummer, may be nearly as warm during the growing season as one in Florida, where there is not more than fourteen hours of sun in a day. Furthermore, a deep pond, besides being colder, may be too deep in the middle for aquatic plants rooted in the soil (such as the Nymphaeaceae) to reach the surface, so that it

* See his Oecology of Plants (1909), pp. 196–199, 200–205.

can be filled only by means of a floating mat of vegetation growing out from the edges.* And plants not connected with the soil, whether epiphytic or floating, cannot grow very fast on account of the dearth of mineral plant food. The peculiarities of bog vegetation have been commonly attributed to the acidity of the water, but the acids in bog water are not a fundamental part of the environment, but are derived from the vegetation, so that offering such an explanation is only reasoning in a circle.†

The size of the basin in which the pond or bog is located also influences the vegetation through the amount of seasonal fluctuation of water (as was observed in Florida a few years ago‡). For considerable fluctuation of water in or above the ground hastens the decay of dead vegetation and the liberation of the food in it, and peat is formed best in places where the water-level is nearly constant.§

The occurrence of typical slow-growing (sometimes erroneously called xerophytic) bog vegetation in flat, slowly drained areas as well as in deep stagnant basins is probably to be explained largely by the fact that seeping water, having just emerged from the ground, is considerably cooler in summer than shallow standing water.‖ The dense growth of conifers in such places still further protects the water from the heat of the sun, after they are once established. Another important factor is that in a perpetually saturated soil the lack of aëration restricts the availability of the mineral plant food in the soil, particularly the potassium compounds. Of course it may be said that the soil of a marsh is also perpetually saturated, which is true enough; but in a marsh, whether stagnant or estuarine, the water has been exposed to evaporation much longer than that in a seepage or spring-fed swamp, and thus the soluble salts in it are more concentrated.

* Probably the best description of this process is that by C. A. Davis in Rep. Mich. Geol. Surv. **1906**: 125–172. 1907.

† For a summary of bog theories, in which however the question of mineral nutrients is hardly considered at all, see G. B. Rigg, Plant World **19**: 310–325. "Oct." [Nov.], 1916.

‡ See Torreya **11**: 225–234. 1911; Ann. Rep. Fla. Geol. Surv. **6**: 202, 203. *figs. 46–48*. 1914.

§ See Ann. Rep. Fla. Geol. Surv. **3**: 211. 1911.

‖ The temperature of springs, other than thermal springs, is usually very close to the average annual temperature of the locality where they occur.

Furthermore, most marsh plants have hollow or spongy stems or petioles, or aerenchyma, or pneumatophores, all of which doubtless serve to conduct air to the roots.

It might be observed here, parenthetically, that many plants which in the region under consideration are chiefly confined to bogs grow equally well on uplands in colder climates.* This is probably because the low temperature and short growing season farther north so limit the availability of the nutrients in the soil that none but slow-growing plants can thrive.

An elaborate system of hypotheses of succession has been postulated by Gates and others who have worked in this or somewhat similar regions, and some have even gone so far as to try to connect all the plant associations in a limited area by successional relations. But some of the imagined successions can never take place without profound topographic changes, which may or may not come to pass, and with which the botanist is not particularly concerned. There are, however, two genuine types of succession (biotic succession as defined by Cowles,† and distinguished from his regional and topographic successions) which can be studied to advantage in this region. The first is that connected with the filling of lakes, etc., with vegetation and the gradual accumulation of peat and humus. In a coniferous swamp the falling leaves, twigs, trunks, etc., gradually pile up high enough above the groundwater level to be subject to ordinary decay, and thus form humus or duff instead of true peat. In such humus grow many plants which are equally characteristic of the upland hardwood forests, and this has led some to believe that the swamps, barring human interference and unforeseen complications, will ultimately be replaced by beech-maple-hemlock forests. But there are quite a number of plants in this region which seem to demand both humus and access to mineral soil or alkaline peat, such as *Acer saccharum*, *Tsuga*, *Fagus*, *Tilia*, *Ulmus*, *Quercus alba*, *Viburnum acerifolium*, *Vagnera racemosa*, *Carex arctata*, *C. laxiflora*, *Washingtonia*, *Actaea alba*, *Circaea*, *Adiantum pedatum*, *Geranium Robertianum*, *Caulophyllum*, and several others less common here, and we have no

* See Livingston, Bot. Gaz. **39**: 40. 1905; Harper, Pop. Sci. Monthly **85**: 340. 1914.

† Bot. Gaz. **51**: 161–183. 1911.

evidence that these will ever grow on top of deep sour peat. Furthermore, the swamps are colder at night than the adjoining slopes, and lack some of the characteristic soil fauna of clayey uplands, and these fundamental differences can hardly be obliterated by succession.

It has been assumed also that the pine forests on the sandy uplands would likewise be succeeded by hardwood forests, if fire and lumbering did not prevent the accumulation of humus. Although the sand is undoubtedly poorer than the clay, one might suppose that in the course of centuries the pines could bring up enough mineral matter from a depth of several feet, and deposit it on the surface in decaying leaves, to make a rich soil that would support trees that make a complete new crop of leaves every year, and that such a forest when once established would be self-perpetuating, as it would return to the soil every fall what it took up in the spring and summer. But the difficulty is that in sandy soils leaching probably goes on fast enough to prevent the accumulation of any considerable amount of plant food on the surface of the ground. (On clayey slopes there is less leaching, and erosion is constantly exposing fresh layers of soil, and thus maintaining its fertility indefinitely.) It seems that in many if not most cases the proportion of deciduous trees in a forest does not increase with succession, but depends on fundamental soil characters.*

Another type of succession is a periodic one resulting from fire. In a state of nature the hardwood forests were rarely visited by fire, and one might say figuratively that the plants in such habitats made no provision for such an occurrence. The pine forests have been so nearly destroyed that it is difficult to determine what the normal frequency of fire in them may have been. As *Pinus resinosa* is not very sensitive, it may have been subject to ground-fires every few years, like some of the southeastern pines;† while in the white-pine forests fire may have been almost as rare as in the hardwoods. Be that as it may, the "pernicious activities" of the lumbermen a few decades ago removed the greater part of these two valuable pines,‡ and the ground formerly occupied by

* See H. W. Wiley, Science II. **17**: 794–795. May 15, 1903; Harper, Bull. Torrey Club **41**: 209–220. 1914; B. Moore, Bot. Gaz. **61**: 59–66. Jan. 1916.

† See Pop. Sci. Monthly **85**: 343. 1914.

‡ The effects of lumbering in this part of Michigan have been described by several

them has now a low scrubby growth of birch and aspen, which is burned too often for the white pine to reëstablish itself, though the red pine is making some headway.

On steep bluffs and small islands, and in ravines, where fire is necessarily rare, we find some plants that are sensitive to fire but do not require as rich a soil as that of the hardwood forests, such as the few woody vines of the region. (Most of the existing white pines are found in such places, too.) The low sandy "ice ramparts" around the larger lakes are protected from fire on one side by the water and at the same time are too sterile to support vegetation dense enough to carry fire readily, so that certain fire-sensitive (or *pyrophobic*, if one may coin a new term) plants, such as *Amelanchier* sp., *Prunus pumila*,* *Rosa* sp., *Rhus Toxicodendron*, *Arctostaphylos Uva-ursi*, *Equisetum hyemale*, *Elymus* sp., and *Potentilla Anserina*, are characteristic of such places.

The normal frequency of fire in the jack-pine and spruce types of forest seems to be about once in the average lifetime of a tree. *Pinus Banksiana* is one of several pines whose cones remain closed and attached to the tree for many years, but open soon after a fire and discharge their seeds, thus re-stocking the forest. In the spruce bogs, as in the white-pine forests, one of the first effects of a fire sweeping through the crowns of the trees is to liberate the potash and other mineral substances stored up in several years' growth of leaves and twigs, which falls to the ground and acts as a high-grade fertilizer. Several quick-growing and short-lived trees and shrubs, such as *Betula*, *Populus tremuloides*, *P. grandidentata*, *Prunus pennsylvanica*, and a few characteristic herbs, known collectively as fire-weeds, soon invade the burned areas by means of seeds carried by wind or birds, and flourish until the surplus potash, etc., is exhausted. In the swamps one of the conifers itself, namely the deciduous one, *Larix*, acts as a sort of fireweed, being especially common in the first few decades after a fire; and its career is commonly terminated by saw-flies instead of fire. As it renews its whole crop of leaves every year it needs a larger food supply than the spruces, and it also extends farther into the

of the writers cited in the bibliography, particularly Dr. Rusby. Dr. H. A. Gleason told me in 1912 that he did not know of a single acre of virgin white-pine forest in lower Michigan.

* See Rhodora **18**: 202. Sept. 1916.

richer regions of southern Michigan, Ohio, etc., than they do. While the fireweeds are flourishing, seeds of the original conifers are being brought in in the regular manner, and by the time the birches and aspens have run their course the conifers that have

FIG. 3. Scene in large tamarack swamp with a few feet of peat, about four miles north of Douglas Lake, bordering a sluggish stream flowing into Carp Lake. Trees in background all or nearly all *Larix laricina*. (See Gates, 1913, pp. 64-66.) Open space in foreground evidently severely burned several years before. Woody plants in it mostly *Larix* seedlings, *Salix pedicellaris*, *Betula pumila*, *Rhamnus alnifolia*, *Chamaedaphne*, *Alnus*, *Lonicera canadensis* and *Ledum*. Evergreens in the minority; little or no sphagnum. (This view was taken a mile or more from the stream, and near the south edge of the swamp, where it is bordered by clayey hills mostly cultivated. Toward the stream the percentage of evergreens increases considerably.)

been growing up in their shade may be ready to dominate the situation again.*

Since the best pines have disappeared the lumbermen have attacked the hardwood forests also, and much hemlock has been destroyed for tan-bark. The slash left from these operations is subject to fire too, but the fireweeds on hardwood land are not quite the same as on pine land. *Sambucus pubens* and *Rubus* spp.

* So many papers have been written about the effects of fire in boreal coniferous forests that it would not be worth while to attempt to cite them here, but references to several of them can be found in Bull. Torrey Club **35**: 349. 1908, and in Pop. Sci. Monthly **85**: 341. 1914.

are quite characteristic, and the vacciniums are rare or absent. A hardwood area after logging, and even after the slash is burned, is very disagreeable to traverse, on account of the numerous logs and tops cumbering the ground, many of the logs being held up by stiff branches at such a height that it is just as hard to climb over them as to crawl under them, and only the smaller branches are consumed by fire, the larger ones making veritable *chevaux-de-frise* that last for many years. (Ten or twelve degrees farther south fallen trees decay much more rapidly, and do not materially impede the explorer after two or three years.*)

Farmers have damaged the vegetation still further by totally eradicating much of it to make room for crops. This influence has been chiefly concentrated on the hardwood land, on account of its richer soil, but only about 17 per cent. of the area was classed as "improved land" in 1910. The extension of farms ought to have one indirect beneficial effect on the pine land, however, by multiplying the barriers to fire and thus diminishing its frequency at any one point.†

Plant census.—The following plant list is based on the writer's observations in northern lower Michigan between June 28 and August 24, 1912. Although only nine of the twenty-one counties were visited in that time, the results are probably representative enough, except for the dunes and cliffs along the Great Lakes, which were not examined. The relative abundance of the species has been determined in the manner explained in several previous papers which are easily accessible.‡ Although some may question the accuracy of my rapid reconnoissance methods, there is probably no one at the present time in a position to assert that the results

* In this connection see W. H. Long, Investigations of the rotting of slash in Arkansas. U. S. Dept. Agr. Bull. 496. Feb. 1917.

Curiously enough, however, twenty degrees farther south the tropical hardwood forests of extreme southern Florida are subject to fire at long intervals, followed by a few characteristic fireweeds (*Trema*, *Carica*, etc.), and are just as disagreeable to traverse for some time afterward as these Michigan forests, on account of the hardness and durability of the wood of many of the trees.

† For an interesting account of the effects of farming on fire frequency in the Ozarks, see Marbut, Field Operations U. S. Bur. Soils **1911**: 1740. 1914. (Or page 20 of the separates.)

‡ Ann. Rep. Fla. Geol. Surv. **6**: 177–180. 1914; Bull. Torrey Club **41**: 557–559. 1914; **44**: 47–50. 1917; Torreya **17**: 1–2, 5–6. 1917.

are incorrect. Future explorations will doubtless necessitate changing the sequence of many of the species remote from the head of the list; but as it is, the present sequence corresponds very well with what one might obtain by counting the number of times each species is mentioned in previous descriptions of the vegetation of the same region.

The species are first divided into large trees, small trees, vines and large shrubs, small shrubs, and herbs. Large trees are large enough to be sawn into lumber, small trees large enough for posts, large shrubs for canes or bean-poles, and so on down. Woody vines are combined with large shrubs, because otherwise in the absence of numbers there would be nothing to indicate how relatively scarce they are, but their names are italicized to distinguish them. Some small evergreen plants which have perennial stems above the ground, such as *Equisetum* spp., *Lycopodium*, *Chimaphila*, *Gaultheria*, *Epigaea*, *Chiogenes*, *Oxycoccus*, *Mitchella*, and *Linnaea* (the "chamaephyte" class of Raunkiaer, in part), are classed with the herbs on account of their small size and lack of true woody tissue.

Evergreens are indicated by heavier type, as usual, and the names of weeds enclosed in parentheses, whether they are treated as exotics in the manuals or not.* The three commonest modes of dissemination are indicated by somewhat arbitrary but suggestive symbols, as follows: wind-borne seeds, Y; fleshy fruits, O; barbed fruits, X. It would have been interesting to indicate annuals, biennials, perennials, etc.† (or better still perhaps the Raunkiaerian growth-forms‡), as well as the blooming periods and color of flowers, but there are too many cases in which these data are not yet known accurately enough. The usual habitats of the different species are given in a few words.

In each major group the species are arranged as nearly as possible in order of present abundance. Very likely a similar census taken fifty years ago would have placed *Pinus Strobus* at the head of the list, and arranged some of the other trees differently, and excluded some of the weeds entirely. On account of

* See Bull. Torrey Club **35**: 347–360. 1908; **37**: 117–120. 1910.

† As in Ann. N. Y. Acad. Sci. **17**: 36–37. 1906, for example.

‡ For an easily accessible reference to Raunkiaer's system, and an illustration of its use, see Taylor, Am. Jour. Bot. **2**: 32. 1915.

the incompleteness of the data, and the great changes that have been made by lumbermen and others, percentage numbers are not attempted. But the numbers when finally determined probably will not depart much from a geometrical progression.* (The commonest herb, however, seems to be about four times as abundant as the next one.) The rarer species, and all cellular cryptogams, are omitted, because they make up such an insignificant part of the total vegetation.

TREES

Y Larix laricina	Swamps and bogs
Thuja occidentalis	" " "
Y **Pinus Strobus**	Sandy uplands, etc.
Y Acer saccharum	Rich uplands
Y **Tsuga canadensis**	" "
Fagus grandifolia	" "
Y **Picea mariana**	Swamps and bogs
Y **Abies balsamea**	" " "
Y Acer rubrum	Various habitats
Y Tilia americana	Rich uplands
Y Fraxinus nigra	Swamps
Y **Pinus resinosa**	Sandy uplands
Y Ulmus americana	Richer soils
Quercus borealis maxima†	Sandy uplands
Y **Picea canadensis**	Swamps and bogs
Y Betula lutea	Rich woods
Y **Pinus Banksiana**	Poorest soils
Quercus alba	Uplands
Y Fraxinus americana	Richer soils

SMALL TREES

Y Betula papyrifera	Various habitats
Y Populus tremuloides	Burned areas mostly
Y Populus grandidentata	" " "
O Prunus pennsylvanica	" " "
Y Populus balsamifera	Lake shores, etc.
Ostrya virginiana	Rich uplands
Y Salix fluviatilis?	Lake shores, etc.

LARGE SHRUBS AND VINES

Alnus incana	Swamps, etc.
Y Salix lucida	Wet places
Y Salix spp‡	Swamps, etc.
Y Acer pennsylvanicum	Rich woods

* See Torreya **13**: 244. Oct. 1913.

† Long known as *Q. rubra*. See Torreya **17**: 135. Aug. 1917.

‡ This includes several unidentified species. If they had been separated they would of course stand lower in the list.

O Sambucus pubens	Burned or cleared hardwood land
O Rhus sp.*	Burned uplands
O Rhus glabra	" "
Y Acer spicatum	Rich woods
O Cornus stolonifera	Low grounds
O Nemopanthes mucronata	Swamps
O Ilex verticillata	Swamps
O Amelanchier sp.	Various habitats
O *Vitis vulpina*	Lake shores and bluffs
Celastrus scandens	Bluffs and islands
O Viburnum cassinoides	Swamps
Y Salix discolor?	Low grounds

SMALLER SHRUBS

Diervilla Lonicera	Sandy uplands
O Rubus strigosus	Burned or cleared hardwood land
Chamaedaphne calyculata	Open bogs
Comptonia peregrina	Sandy uplands
O Rubus allegheniensis?	Burns, clearings, etc.
O Rhus Toxicodendron	Ice-ramparts, etc.
Ledum groenlandicum	Bogs and swamps
Y Salix rostrata?	Swamps
O Vaccinium pennsylvanicum	Sandy uplands
O **Taxus canadensis**	Rich woods and swamps
O Rhamnus alnifolia	Bogs and swamps
Myrica Gale	" " "
O Vaccinium canadense	Sandy uplands
Y Betula pumila	Bogs and swamps
O Lonicera canadensis	" " "
O **Arctostaphylos Uva-ursi**	Barren sands
O Rosa sp.	Lake shores, etc.
Spiraea latifolia	Swamps and meadows
O Viburnum acerifolium	Rich woods and bluffs
Decodon verticillatus	Swamps and marshes
Andromeda glaucophylla	Open bogs
O Aronia nigra	Bogs, etc.

(and about 15 others)

HERBS

Y Pteris aquilina	Sandy uplands, etc.
Y Typha latifolia	Marshes, etc.
Y Chamaenerion angustifolium	Burns and clearings
(Poa pratensis)	Roadsides, etc.
Calamagrostis canadensis	Marshes
O Aralia nudicaulis	Rich woods, shady bogs, etc.
O Unifolium canadense	" " " " "
Y (Solidago canadensis)	Fields and roadsides

* The sumacs of this region present a bewildering variety of forms, ranging from the perfectly smooth *R. glabra* to some almost pubescent enough to be called *R. typhina*; but no typical *R. typhina* was observed.

Y (Asclepias syriaca)	Fields and roadsides
(Achillea Millefolium)	" " "
Scirpus validus	Lakes, etc.
Carex filiformis	Bogs and marshes
Y Dryopteris Thelypteris	" " "
O **Gaultheria procumbens**	Sour soils, dry or moist
O Cornus canadensis	Rich woods and bogs.
Dulichium arundinaceum	Marshes, etc.
(Verbascum Thapsus)	Pastures, roadsides, etc.
Y Eupatorium purpureum	Swamps and meadows
O Clintonia borealis	Rich woods and shady bogs
Nymphaea variegata*	Quiet water
Scirpus americanus	Lake shores, etc.
O Rubus triflorus	Bogs and swamps
O Vagnera racemosa	Rich woods
Iris versicolor	Marshes
Y Osmunda regalis	Swamps and marshes
Y Scirpus cyperinus pelius	Marshes and meadows
Comarum palustre	Marshes, etc.
Y Eupatorium perfoliatum	Meadows, etc.
Triadenum virginicum	Bogs and marshes
Trientalis americana	Rich woods and shady bogs
Y Asclepias incarnata	Marshes, etc.
O Vagnera trifolia	Rich woods and shady bogs
O **Chiogenes hispidula**	" " " " "
Y Onoclea sensibilis	Marshes, etc.
Lysimachia terrestris	" "
(Pastinaca sativa)	Roadsides
O **Mitchella repens**	Rich woods mostly
Potentilla Anserina	Lake shores
Carex arctata	Rich woods and bluffs
Coptis trifolia	Rich woods and shady bogs
Spartina Michauxiana	Lake shores, etc.
Lathyrus palustris	" " "
Y (Leptilon canadense)	Burns and waste places
(Equisetum arvense)	Along railroads, etc.
O **Linnaea americana**	Rich woods and shady bogs
Y **Lycopodium annotinum**	" " " " "
Lilium philadelphicum	Swamps and meadows
Thalictrum dasycarpum	" " "
(Chrysanthemum Leucanthemum)	Roadsides, etc.
Danthonia spicata	Sandy uplands
Equisetum palustre	Swamps and bogs
Equisetum hyemale	Lake shores, etc.
X (Cynoglossum officinale)	Roadsides
X Washingtonia Claytoni	Rich woods
O Actaea alba	" "

* For a discussion of the nomenclature of this plant, see Fernald & St. John, Rhodora **16**: 137–141. Aug. 1914.

	Mitella nuda	Rich woods and bogs
	Epigaea repens	Sour soils
	Campanula uliginosa	Marshes
	Equisetum fluviatile	"
O	Aralia racemosa	Rich woods
	(Convolvulus spithamaeus)	Sandy uplands
Y	Apocynum androsaemifolium	" "
	(Phleum pratense)	Roadsides, etc.
	Menyanthes trifoliata	Bogs and marshes
	Eleocharis palustris	Shallow water
O	Trillium grandiflorum	Rich woods
	Cladium mariscoides	Lake shores
Y	Eriophorum viridicarinatum	Bogs, etc.
O	**Oxycoccus macrocarpus**	Bogs
Y	(Apocynum cannabinum)	Ice ramparts, etc.
	Oryzopsis asperifolia	Sandy bluffs, etc.
X	Circaea alpina	Rich woods
X	(Arctium minus)	Waste places
Y	Euthamia sp.	Lake shores, etc.
	Equisetum laevigatum	" " "
	Botrychium virginianum	Rich woods
	Panicum depauperatum	Sandy uplands
	Equisetum scirpoides	Bogs
Y	Aster macrophyllus	Rich woods, etc.
	Scirpus atrovirens	Meadows, etc.
	(Ambrosia artemisiifolia)	Waste places
	Lobelia cardinalis	Along brooks
	Caltha palustris	" "
X	Galium triflorum	Rich woods
	Geranium Robertianum	" "
	(Trifolium pratense)	Roadsides, etc.
	(Trifolium repens)	" "
O	Polygonatum biflorum	Rich woods
	Naumburgia thyrsiflora	Marshes
	Comandra umbellata	Sandy uplands
Y	**Dryopteris spinulosa**	Rich woods
	Elymus sp.	Lake shores
	Phalaris arundinacea	" "
	Cypripedium hirsutum	Shady bogs

Summary.—The species above listed probably constitute something like nine tenths of the vegetation and one tenth of the flora of the region under consideration. About 275 additional species, nearly all herbs, were observed, but not often enough to be worth mentioning.

Not one of the large trees has fleshy or barbed fruits, while few of the smaller shrubs are wind-distributed. There are no barbed fruits on any of the woody plants, but a few of the small trees and

many of the shrubs, vines and herbs have fleshy fruits.* Herbs with barbed fruits are in this region chiefly confined to rich woods and roadsides, probably partly because of the exemption of such places from fire,† though it is not at present apparent why that should affect them more than it does the fleshy fruits. (Barbed fruits seem to be more characteristic of warmer climates and more calcareous soils, too.) Plants with erect capsules on stiff stems which stand up through the winter (called "tonoboles" by Clements‡) are much rarer here than a few degrees farther south, possibly because the snow interferes with their dissemination.

About half the large trees are evergreen, but none of the small trees, vines and large shrubs are, strange to say. It would seem from this that no evergreens except conifers (and one of those is deciduous) can stand the Michigan winters without the protection of snow.§ Vines are scarce, only two being listed, and those are not found much farther north.

The Ericaceae and allied families are largely represented among the small shrubs and evergreen herbs, as in many other places with similar climate. Other families pretty well represented in proportion to the total number of species in them, or the total flora of this region, or both, are Equisetaceae, Cyperaceae, Orchidaceae, Salicaceae, Rosaceae, and Caprifoliaceae, while the opposite might be said of the Fagaceae, Cruciferae (native), Caryophyllaceae (native), Leguminosae, Polygalaceae, Violaceae, Hypericaceae, Umbelliferae, Labiatae, Scrophulariaceae, and Lentibulariaceae, The sedges seem to be more numerous and also more abundant than the grasses.

Nearly all the species listed are widely distributed, extending from Nova Scotia to Minnesota at least, and most of them are represented in northern Europe by identical or closely related forms. Those peculiarly American plants which are confined to

* See Torreya **14**: 16. 1914.

† See Torreya **17**: 138–139. 1917. (In the text on page 138 *Allium* and *Deringa* were included inadvertently, and should be striken out.) Two additional references that should have been given there are: S. M. Coulter, Rep. Mo. Bot. Gard. **15**: 44. 1904; Harper, Torreya **10**: 60–61. 1910.

‡ Bot. Surv. Neb. **7**: 47. 1904.

§ In this connection see Gates, Torreya **12**: 257–262. 1912; Harper, Rep. Mich. Acad. Sci. **15**: 194. 1914.

the glaciated region and coastal plain or nearly so* are scarcely represented here, presumably because the climate is a little too cold.

A list of the commoner plants of the eastern part of the Upper Peninsula, based wholly on car-window notes, was published by the writer a few years ago.† In that a slightly different method of computation, which did not do justice to the conifers, was used, and the different sizes of trees and shrubs were not separated. But it is probably safe to say that *Abies*, *Picea canadensis*, *Betula pumila*, and *Andromeda glaucophylla* (to mention woody plants only) are more abundant in the Upper Peninsula than here; while the reverse is true of *Acer saccharum*, *Tsuga*, *Fagus*, *Tilia*, *Ulmus*, *Acer pennsylvanicum*, *Sambucus*, *Rhus glabra* (etc.), *Diervilla*, *Rubus strigosus*, *Comptonia*, *Rubus allegheniensis* (?), *Rhus Toxicodendron*, *Taxus canadensis*, and a few others, most of which are not evergreen.

Comparing this region with that adjoining it on the south we get a greater contrast, due to better soil and climate both. The commonest trees in the central third of lower Michigan (not counting the lake plains around Saginaw Bay, which are still more fertile), as determined from a few hours of car-window observations, seem to be as follows:

Quercus velutina (?), *Pinus Banksiana*,‡ *P. Strobus*, *Ulmus americana*, *Larix laricina*, *Quercus borealis maxima* (?), *Acer saccharum*, *Fagus*, *Thuja*, *Tsuga*, *Abies*, *Tilia*, *Pinus resinosa*, *Quercus alba*, and *Picea mariana*.

Still farther south the change in composition of vegetation continues in the same direction, and in extreme southern Michigan nearly all the trees are deciduous.

COLLEGE POINT,
NEW YORK

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* See Rhodora **7**: 69–80. 1905; **8**: 27–30. 1906.

† Rep. Mich. Acad. Sci. **15**: 193–198. 1914.

‡ If I had left northern Michigan by way of the Michigan Central R. R. instead of the Pere Marquette, *Pinus Banksiana* would doubtless have stood higher in the first list and lower in the one on this page; for along the former railroad it is said to be abundant in Crawford and Roscommon Counties, while along the latter I saw it mostly in Lake and Newaygo Counties, south of the limits assigned in this paper. (See second map between pages 550 and 551 of the 9th volume of the Tenth Census.)

INDEX TO AMERICAN BOTANICAL LITERATURE

1913-1917

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

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Translated from the English text by Brother Léon. Reprinted as Contr. N. Y. Bot. Gard. 194: 1–16. Je 1917.

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Collins, F. S., & Hervey, A. B. The algae of Bermuda. Proc. Am. Acad. Arts and Sci. **43**: 1–195. *pl. 1–6*. [31] Au 1917.

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